(12) UK Patent Application (19) GB (11) 2 351 360 (13) A

(43) Date of A Publication 27.12.2000

(21) Application No 0015045.8

(22) Date of Filing 21.06.2000

(30) Priority Data
(31) 232731999 (32) 21.06.1999 (33) KR

(51) INT CL^7
G02B 6/34

(52) UK CL (Edition R)
G2J JGDBG

(56) Documents Cited
EP 0639782 A1 US 5559915 A

(58) Field of Search
UK CL (Edition R) G2J JGDBG
INT CL^7 G02B
Online: EPODOC, PAJ, WPI

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(54) Abstract Title
AWG WDM with alignment waveguides and aligning apparatus

(57) An arrayed waveguide grating (AWG) 203 wavelength division multiplexer (WDM) that is provided with alignment waveguides 250 and an apparatus for aligning the AWG WDM. The WDM comprises functional waveguides 205 and alignment waveguides. Signals distributed to the functional waveguides are WD multiplexed or de-multiplexed by means of the AWG, but signals distributed to the alignment waveguides are not. The WDM may comprise star couplers 202, 204. The aligning apparatus comprises light source 300, measuring unit 308 for measuring the intensity of the light and control unit 310 which positions fibre blocks 302, 304, 306 in order to maximise light intensity.

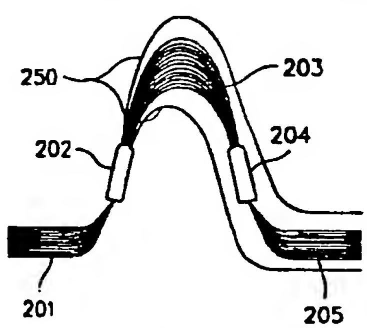

FIG. 2

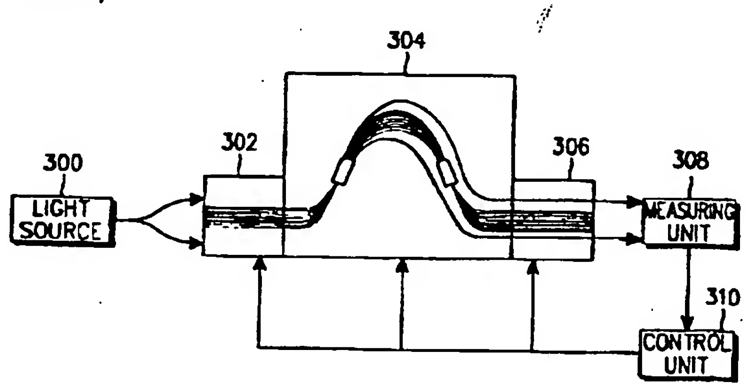

FIG. 3A

GB 2 351 360 A

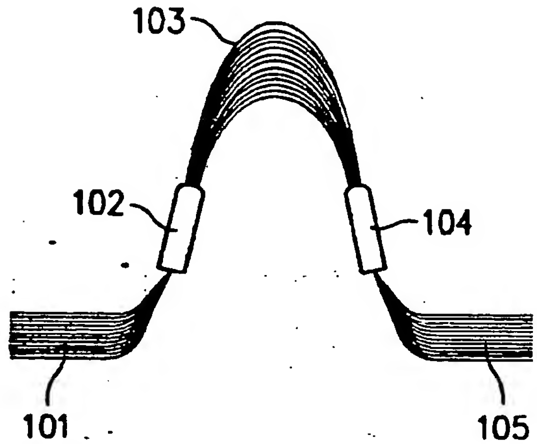

FIG. 1A

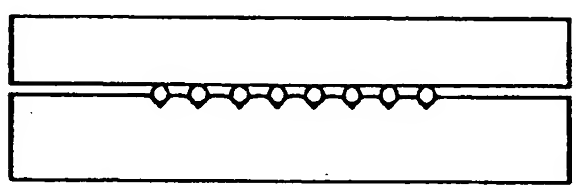

FIG. 1B

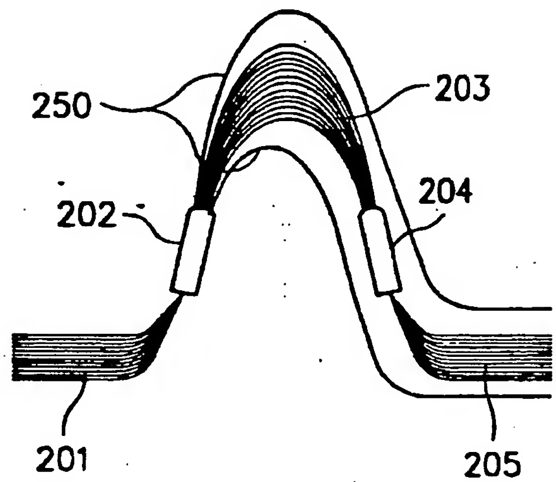

FIG. 2

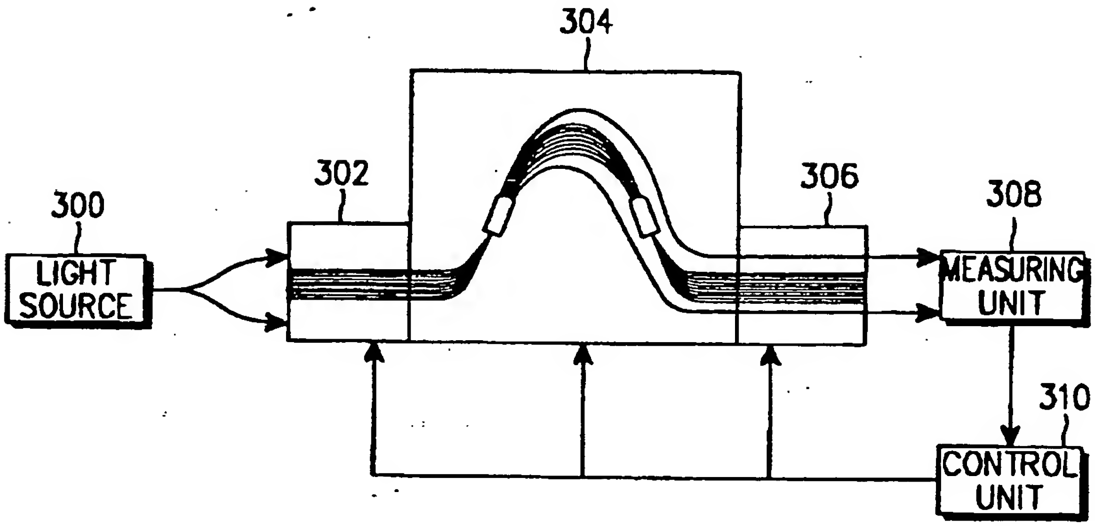
304
302
306
308
300
LIGHT SOURCE
MEASURING UNIT
310
CONTROL UNIT

FIG. 3A

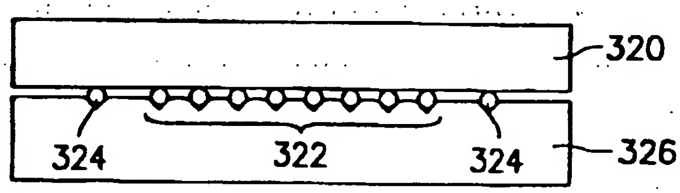
320
324
322
324
326

FIG. 3B

1

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AWG WDM WITH ALIGNMENT WAVEGUIDES AND ALIGNING APPARATUS

BACKGROUND TO THE INVENTION

The present invention relates to an arrayed waveguide grating (AWG) wavelength division multiplexer (WDM) provided with alignment waveguides and an apparatus for aligning the AWG WDM.

Generally, a waveguide type optical device when bonded to optical fibres should be aligned with those optical fibres so that it is practically useful in a transmission network. Typically, in the bonding and alignment of the optical devices, light is first incident on an input optical fibre array. Using the incident light, the input optical fibre array is then aligned with an input waveguide array of the optical device. Thereafter, an output optical fibre array is aligned with an output waveguide array of the optical device so as to allow the light to be transmitted to two ports positioned at respective ends of the output optical fibre array. Detection of the intensity of the light guided to the ports is then carried out. Based on the results of this detection, the relative position of each optical fibre array and the optical device is finely adjusted to find a position where light is transmitted with maximum intensity. At this position, the associated optical fibre array is then bonded to the optical device.

Fig. 1a illustrates a conventional WDM. Fig. 1b is a cross-sectional view illustrating an optical fibre block

aligned with the WDM of Fig. 1a.

The WDM shown in Fig. 1a includes an input waveguide array 101, a first star coupler 102, an arrayed waveguide grating (AWG) 103, a second star coupler 104 and an output waveguide array 105. An optical fibre block shown in Fig. 1b is aligned with and bonded to each of the input and output waveguide arrays 101 and 105.

Where an optical device, such as the above mentioned WDM, is to be aligned with and bonded to an optical fibre block, it is necessary to align accurately the optical device and optical fibre block while taking into consideration the wavelength characteristics of the optical device to find an optimum bonding position. However, since the wavelength characteristics of the optical device may vary during the manufacture of that optical device, they must be determined prior to the alignment process. Furthermore, it is often necessary to use a number of complex devices, for example, a number of light sources.

For a WDM as mentioned above, it is also important to monitor the optical signal transmitted through the WDM at an optical position of the WDM in real time. In a conventional monitoring method, signal information output from each port of the WDM is read to detect the wavelength of the optical signal. In accordance with this method, however, it is necessary to directly input, to a detector, the optical signal output from the end of a transmission line or the output end of the WDM. For this

reason, it is impossible to achieve wavelength detection during transmission of the optical signal.

SUMMARY OF THE INVENTION

Therefore, an object of the invention is to address the shortcoming identified above.

Accordingly, in a first aspect the present invention provides a WDM comprising means for distributing optical signals received from a plurality of input waveguides to a plurality of output waveguides and a plurality of alignment waveguides, in which the signals distributed to the plurality of output waveguides are WD multiplexed or demultiplexed and the signals distributed to the plurality of alignment waveguides are not.

Preferably, the WDM comprises:

means for distributing optical signals received from the plurality of input waveguides to a plurality of intermediate waveguides of different optical lengths and the plurality of alignment waveguides; and

a plurality of output waveguides adapted to receive optical signals produced by interference between the outputs of the intermediate waveguides.

The plurality of intermediate waveguides may be of different physical lengths.

Preferably, the output terminals of the plurality of intermediate waveguides are spatially arrayed and the output terminals of the plurality of alignment waveguides

are peripheral to the array of output terminals of the intermediate waveguides. For example, the output terminals of the plurality of intermediate waveguides and the plurality of alignment waveguides may be uniformly linearly arrayed and the output terminals of the plurality of intermediate waveguides arrayed in order of optical length of the intermediate waveguides.

In another aspect, the present invention provides apparatus for aligning, with a plurality of optical fibres, a WDM comprising means for distributing optical signals received from a plurality of input waveguides to a plurality of output waveguides and a plurality of alignment waveguides, in which the signals distributed to the plurality of output waveguides are WD multiplexed or demultiplexed and the signals distributed to the plurality of alignment waveguides are not, the apparatus comprising:

a light source;

a first optical fibre block having a plurality of optical fibres that are adapted to transmit light emitted from the light source to the means for distributing optical signals of the WDM as the said plurality of input waveguides;

a second optical fibre block having a plurality of alignment optical fibres adapted for alignment with the plurality of alignment waveguides of the WDM and a plurality of functional optical fibres adapted for alignment with the plurality of output waveguides of the WDM;

means for measuring the quantity of light output from the alignment optical fibres of the second optical

fibre block; and

a control unit for adjusting the positions of the first and second optical fibre blocks and the wavelength division multiplexer to respective positions at which the measured quantities of light are maximised.

Preferably, the input terminals of the plurality of functional optical fibres are spatially arrayed and the input terminals of the plurality of alignment optical fibres are peripheral to the array of output terminals of the intermediate waveguides. For example, the input terminals of the plurality of functional optical fibres and the plurality of alignment optical fibres may be uniformly linearly arrayed.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1a illustrates a conventional WDM;

Fig. 1b is a cross-sectional view illustrating an optical fibre block aligned with the WDM of Fig. 1a;

Fig. 2 illustrates an AWG WDM according to the present invention;

Fig. 3a is a block diagram illustrating an apparatus for aligning the above mentioned WDM having alignment waveguides in accordance with the present invention; and

Fig. 3b is a cross-sectional view illustrating the second optical fibre block shown in Fig. 3a.

DETAILED DESCRIPTION

Fig. 2 illustrates an AWG WDM according to the present invention. As shown in Fig. 2, the WDM includes an input waveguide array 201, a first star coupler 202, an AWG 203, a second star coupler 204, an output waveguide array 205 and a plurality of alignment waveguides 250.

The first star coupler 202 serves to distribute input light received from the input waveguide array 201. The AWG 203 allows optical waves emerging from the first star coupler 202 to have different phases. The second star coupler 204 serves to generate an interference among the optical waves with different phases, received from the AWG 203, thereby focusing those optical waves on different output positions. The focused optical waves are then output to the output waveguide array 205.

The alignment waveguides 250 receive light emerging from the first star coupler 202 and guide the light received to an output terminal of the WDM irrespective of the wavelengths of the light. Accordingly, it is possible to detect the intensity of the light, transmitted irrespective of wavelength, at the output terminal of the WDM. Although the intensity of the output light detected at the output terminal of the WDM exhibits a loss of about 25 dB, as compared to that of the input light, this intensity is enough to be used for alignment of the WDM with optical fibres. The alignment waveguides 250 are positioned at outermost positions on the output terminal of the WDM. Accordingly, where the WDM is aligned with optical fibre blocks using the alignment waveguides 250, the remaining waveguides are naturally aligned with those

optical fibre blocks.

Since each alignment waveguide 250 directly outputs the light, received from the first star coupler 202, to the output terminal while preventing that light from passing through the second star coupler 204, the light emerging from the alignment waveguide 250 has information about all wavelengths of the light incident on the input waveguide array 201. For example, where the WDM operates as a wavelength divider, a signal composed of optical signals with different wavelengths is incident on the input waveguide array 201 and then distributed to the AWG 203 and the alignment waveguides 250 at the output end of the first star coupler 202. Light emerging from the AWG 203 interferes while passing though the second star coupler 204, so that light having different wavelengths are output from the output waveguide array 205. However, light passing through the alignment waveguides 250 are output with the entire wavelength information.

Where the WDM operates as a wavelength coupler, light having different wavelengths is input to respective waveguides of the input waveguide array 201. This light is distributed to the AWG 203 and the alignment waveguides 250 at the output end of the second star coupler 202. The light emerging from the AWG 203 interferes while passing through the second star coupler 204, so that it is output from the output waveguide array 205 with the entire wavelength information. Meanwhile, light passing through the alignment waveguides 250 travels to the output terminal of the WDM without any interference.

Accordingly, it is possible to detect the wavelengths of the light passing through the WDM by measuring the wavelengths of the light at respective output ends of the alignment waveguides 250.

Fig. 3a is a block diagram illustrating an apparatus for aligning the above mentioned WDM having the alignment waveguides in accordance with the present invention. Fig. 3b is a cross-sectional view illustrating a second optical fibre block shown in Fig. 3a.

As shown in Fig. 3a, the aligning apparatus includes a light source 300, a first optical fibre block 302, a WDM 304, which is provided with alignment waveguides, a second optical fibre block 306, a measuring unit 308 and a control unit 310. The WDM 304 has the same configuration as that of the WDM shown in Fig. 2. The second optical fibre block 306 has the configuration shown in Fig. 3b.

The optical fibre block shown in Fig. 3b includes an upper body 320, a plurality of functional optical fibres 322 coupled to the output waveguide array of the WDM 304 and a lower body 326 mounted with the optical fibres 322.

The procedure of aligning the WDM using the above mentioned aligning apparatus will now be described with reference to Fig. 3a. In accordance with the aligning procedure, light emitted from the light source 300 is incident on the WDM 304 after passing through the first optical fibre block 302. The incident light from the

first optical fibre block 302 is partially input to the alignment waveguides 250 shown in Fig. 2. The WDM 304 is coupled at its output terminal to the optical fibre block 304. When alignment optical fibres 324, which are shown in Fig. 3b, are aligned with respective alignment waveguides, functional optical fibres 322 are automatically aligned with respective output waveguides of the WDM 304. The measuring unit 308 measures the intensity of light output from the alignment optical fibres 324. Based on the measured light intensity, the control unit 310 controls the alignment of the first optical fibre block 302, WDM 304 and second optical fibre block 306 with one another so that the intensity of the light output from each functional optical fibre 322 is identical to the measured light intensity. After completion of the alignment, the aligned first optical fibre block 302, WDM 304 and second optical fibre block 306 are bonded together.

The measuring unit 308 may also measure respective wavelengths of light output from the alignment optical fibres 324.

As is apparent from the above description, the present invention provides an optical waveguide device, such as an AWG WDM, which is provided with alignment waveguides, to be used upon coupling the optical waveguide device to optical fibre blocks, in addition to waveguides required for the achievement of desired functions, so that it can achieve a desired alignment irrespective of the achievement of those functions. Accordingly, it is unnecessary to know the operational characteristics of individual

devices and easy and rapid alignment and bonding can be achieved. In addition, the configuration of the aligning and bonding device can be simplified. In accordance with the present invention, the operating wavelength of the optical wavelength device can be determined by detecting the wavelength of the light output from each alignment waveguide. Accordingly, it is simple to determine whether the optical waveguide device is operating normally.

CLAIMS

1. A WDM comprising means for distributing optical signals received from a plurality of input waveguides to a plurality of output waveguides and a plurality of alignment waveguides, in which the signals distributed to the plurality of output waveguides are WD multiplexed or demultiplexed and the signals distributed to the plurality of alignment waveguides are not.

2. A WDM according to claim 1 comprising:

means for distributing optical signals received from the plurality of input waveguides to a plurality of intermediate waveguides of different optical lengths and the plurality of alignment waveguides; and

a plurality of output waveguides adapted to receive optical signals produced by interference between the outputs of the intermediate waveguides.

3. A WDM according to claim 2 in which the plurality of intermediate waveguides are of different physical lengths.

4. A WDM according to claim 2 or claim 3 in which the output terminals of the plurality of intermediate waveguides are spatially arrayed and the output terminals of the plurality of alignment waveguides are peripheral to the array of output terminals of the intermediate waveguides.

5. A WDM according to claim 4 in which the output

terminals of the plurality of intermediate waveguides and the plurality of alignment waveguides are uniformly linearly arrayed and the output terminals of the plurality of intermediate waveguides are arrayed in order of optical length of the intermediate waveguides.

6. A WDM according to any one of claims 2-5 in which the plurality of intermediate waveguides constitute an arrayed waveguide grating.

7. A WDM according to any one of claims 2-6 further comprising a star coupler for interfering the outputs of the intermediate waveguides for reception by the plurality of output waveguides.

8. A WDM according to any preceding claim in which the means for distributing optical signals received from the input waveguides comprises a star coupler.

9. An AWG WDM substantially as described herein with reference to Figs. 2 et seq. of the accompanying drawings.

10. Apparatus for aligning, with a plurality of optical fibres, a WDM comprising means for distributing optical signals received from a plurality of input waveguides to a plurality of output waveguides and a plurality of alignment waveguides, in which the signals distributed to the plurality of output waveguides are WD multiplexed or demultiplexed and the signals distributed to the plurality of alignment waveguides are not, the apparatus com-

prising:

a light source;

a first optical fibre block having a plurality of optical fibres that are adapted to transmit light emitted from the light source to the means for distributing optical signals of the WDM as the said plurality of input waveguides;

a second optical fibre block having a plurality of alignment optical fibres adapted for alignment with the plurality of alignment waveguides of the WDM and a plurality of functional optical fibres adapted for alignment with the plurality of output waveguides of the WDM;

means for measuring the quantity of light output from the alignment optical fibres of the second optical fibre block; and

a control unit for adjusting the positions of the first and second optical fibre blocks and the wavelength division multiplexer to respective positions at which the measured quantities of light are maximised.

11. Apparatus according to claim 10, in which the means for measuring the quantity of light output from the alignment optical fibres comprises a measuring unit for measuring the intensity of the light so output.

12. Apparatus according to claim 10 or claim 11 in which the input terminals of the plurality of functional optical fibres are spatially arrayed and the input terminals of the plurality of alignment optical fibres are peripheral to the array of output terminals of the intermediate waveguides.

13. Apparatus according to claim 12 in which the input terminals of the plurality of functional optical fibres and the plurality of alignment optical fibres are uniformly linearly arrayed.

14. Apparatus for aligning, with a plurality of optical fibres, a WDM comprising means for distributing optical signals received from a plurality of input waveguides to a plurality of output waveguides and a plurality of alignment waveguides, in which the signals distributed to the plurality of output waveguides are WD multiplexed or demultiplexed and the signals distributed to the plurality of alignment waveguides are not, the apparatus being substantially as described herein with reference to Figs. 2 et seq. of the accompanying drawings.

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Application No:	GB 0015045.8	**Examiner:**	Conal Clynch
Claims searched:	1-14	**Date of search:**	15 August 2000

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): G2J (JGDBG)

Int Cl (Ed.7): G02B

Other: Online: EPODOC, PAJ, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0639782 A1	(NIPPON) see Fig 5, 18, 20, 21, 38b & column 1 lines 1-11, from column 13 line 26 to column 14 line 14 & from column 27 line 2 to column 28 line 23	1-3 & 6-7
Y	EP 0639782 A1	(NIPPON) see Fig 5, 18, 20, 21, 38b & column 1 lines 1-11, from column 13 line 26 to column 14 line 14 & from column 27 line 2 to column 28 line 23	10 & 11
Y	US 5559915 A	(LUCENT) see Figs 10-15 & column 1 line 23 & from column 12 line 20 to column 14 line 14	10 & 11

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.